# Marine Protected Area Networks and Rockfish in the Salish Sea: Research Directions

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In the Salish Sea, brown, copper, and quillback rockfish (*Sebastes auriculatus, S. caurinus, and S. maliger*;) have declined significantly from historical levels. A network of MPAs that provide harvest and bycatch refugia for rockfish seem to be an ideal recovery tool (Berkeley et al. 2004). Ideally, these MPAs would be located in order to optimize larval dispersal and functionally protect critical life stages habitats (Gaines et al. 2003). Understanding larval dispersal, habitat use and availability for various life stages, ecological interactions, and oceanographic circulation, then, are some of the important requisites to the successful design and evaluation of MPA networks. Also important are considerations such as feasibility, community support, and compliance (Mascea 2003). Following is a short review of the present status of MPAs within the Salish Sea and research pertaining to their potential to function as a network. I offer recommendations for future research in this realm as well.

Rockfish are generally long-lived and late to mature. It has long been known that old, large female fish produce exponentially more offspring. In black rockfish (*S. melanops*), it has been shown that these females produce healthier progeny that grow faster and survive longer periods of starvation. Also, disproportionately few spawners, mostly large and old, produce offspring that survive to recruitment. Even moderate fishing effort removes these large fish and dramatically reduces the population's reproductive potential (Berkeley et al. 2004). These species have small home territories as adults, making larvae the primary mode of dispersal (Eisenhardt 2003).

The decline of Salish Sea rockfish is mostly due to overharvest, including bycatch (Stout et al.2001). Fish in near urban areas also are at risk from pollution (West and O'Neill 1998). Habitat modification is also an issue. In the Puget Sound, these factors have reduced some *Sebastes* species to 10% of historic reproductive potential (Palsson 1998). In 2001, *S. auriculatus, S. caurinus, and S. maliger* were denied status as threatened or endangered under the Endangered Species Act (ESA). Although distinct population segments (DPSs) were recognized within the sound as separate from the coastal populations, the stability of these DPSs over the last five years precluded listing under the ESA. The biological review team voiced concern, however, with the uncertainty associated with this decision (Stout et al. 2001).

Groups that have responded to the decline in rockfish and other species with the creation of MPAs and MPA network initiatives include federal and state or provincial agencies, tribes, private organizations, and local governments. WDFW has established 15 marine reserves throughout Puget Sound varying in size from 3 to 454 acres. Management goals include the protection of rockfish and the establishment of a scientifically based MPA network (Palsson 2001). The Northwest Straits Commission and Marine Resource Councils of local governments are working to form a scientifically based network of MPAs (Seadoc Society 2004). Twenty-three sites in the Northwest Straits protect rockfish to some degree (Smukler 2002). These include the voluntary reserves established by San Juan County. Similar reserves are scheduled for Skagit County (McConnell and Dinnell 2001). The Puget Sound Action Team created and is overseeing an MPA coordination group (Seadoc Society, 2004). In Canada, proposals include a Gulf Islands Marine Conservation area in conjunction with the national park and a MPA at Race Rocks (Heronwood, 2003). Also at the proposal stage is Orca Pass, an international stewardship area that would cover area between the Gulf Islands and San Juan Islands (Sato and Bloch 2001).

Theoretical studies of larval transport relating to MPA network design make strong assumptions, the validity of which may affect their results and associated recommendations. The most common assumption is of passive larval transport. Several studies have used the GNOME surface circulation model that was developed by NOAA for oil spill preparedness. Kendall and Picquelle (2001) modeled larval dispersal with respect to the 16 MPA sites in the San Juan Islands. Their model predicted an increase by a factor of 5.5 in larval production and an increase by 1.2 of larvae detectable through a plankton tow. The assumptions of this model including: passive transport, the predicted population dynamics, and a uniform distribution of adult rockfish outside the reserve, make their results dubious. Kim Engie used a similar model to predict connectivity of marine reserves within Puget Sound. This study was useful in illustrating likely areas of larval retention, but still was weakened by the passive transport assumption. Moving from computer modeling to empirical experimentation, Klinger and Ebbesmeyer (2001) tracked the final destinations of 6400 drift cards released from the San Juan Archipelago. The areas of accumulation were similar to Engie's model. These models may yield useful and perhaps valid results, but their assumption should not go

unquestioned and the ramifications of more realistic scenarios should be examined. It has been shown, for instance, that observed dispersal distances in Black Rockfish are inconsistent with purely passive dispersal. This is possibly an effect of behavior such as schooling or rheotaxis (Miller and Shanks 2004).

To improve upon our understanding of larval dispersal and sub-population connectivity, researchers have turned to tools such as genetics (Buannoccorsi et al. 2004) or otolith microchemistry (Miller and Shanks 2004, Klinger et al. in press). Further attention given to larval behavior may allow improved models and better understanding of dispersal.

Monitoring the biological response to MPAs has been undertaken by various studies. Most compare fished to reserve sites (Palsson 1998; Palsson 2003; Eisenhardt 2001; Tuya et al. 2000). Edmond's Underwater Park had high densities of large fish through 1997, but by 2003, numbers had declined substantially. There is conflicting evidence as to the effectiveness of the San Juan Archipelago sites, but the MPAs seem to be having a positive effect on densities of larger rockfish, although their numbers are greatly depressed due to fishing pressure (Eisenhardt 2001). It seems likely that lingcod may be limiting rockfish populations in many if not all of the reserves (Palsson 2003). Many of these studies suffer from the classic difficulty in MPA science of developing a meaningful baseline or control. The relatively young age of the San Juan reserves may also preclude conclusive results at this point.

Stakeholder input and support is essential to long-term success of MPAs (Mascea 2003). While San Juan and Skagit County made some effort to include stakeholder, this factor seems overlooked in most of the other literature related to Puget Sound MPAs. Additionally, too little research has been done on the levels of MPA compliance or paths for improvement. Without compliance, MPAs are no different from unprotected areas; without knowledge of compliance levels, we can say less about effectiveness, especially where there are negative or neutral results.

An additional complication that could use more attention is the transboundary nature of rockfish stocks. Many of the studies work only on one side of the US-Canada border. For instance, the northern and western boundaries of the DPSs identified are uncertain, partially for this reason (Stout et al. 2001). Clearly, network design and rockfish research should be transboundary efforts.

Although much good research and organization effort is being put into the idea of MPA networks in the Salish Sea, there is room for improvement. In order to model connectivity, we must develop a better understanding of larval transport and recruitment dynamics and consider the ramifications of non-passive dispersal. In general, early life stages of rockfish could be better understood, including habitat use and vulnerability to impacts in addition to targeted harvest. It is important that monitoring of populations within and outside of the current protected areas be monitored for time series and statistical purposes. Compliance (how to measure it and how to achieve it) should be further examined as well. Future MPA planning should include significant thought to social factors. Transboundary collaboration efforts should continue to be pursued in both management and scientific realms. Lastly, we should apply careful thought as to whether an MPA network is the best tool to turn to in rockfish conservation in the Salish Sea.

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